Inventor: DiFoggio
Title: A Method And Apparatus For Downhole Quantification...
Serial No.: 10/798,686; Filed: March 11, 2004;
Confirmation No.: 6263; Docket No.: 584-30872-US

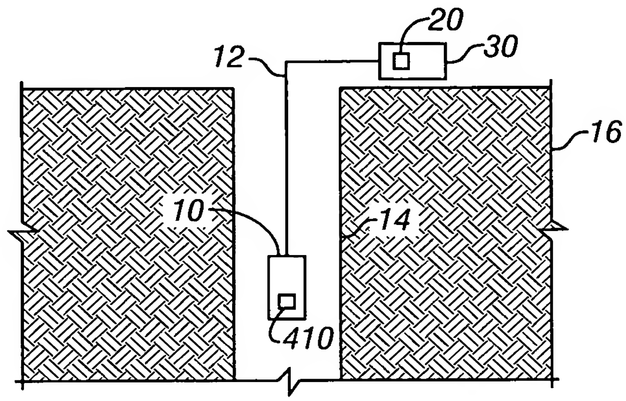

FIG. 1

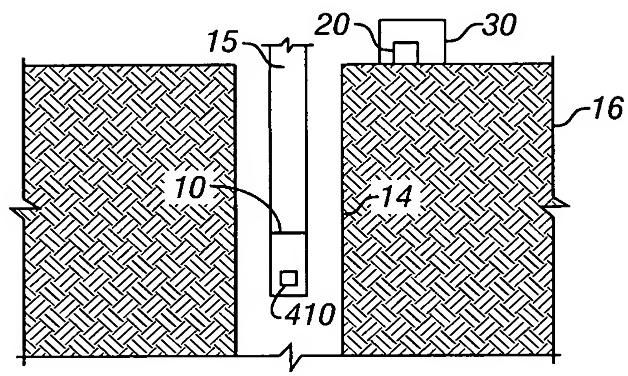

FIG. 2

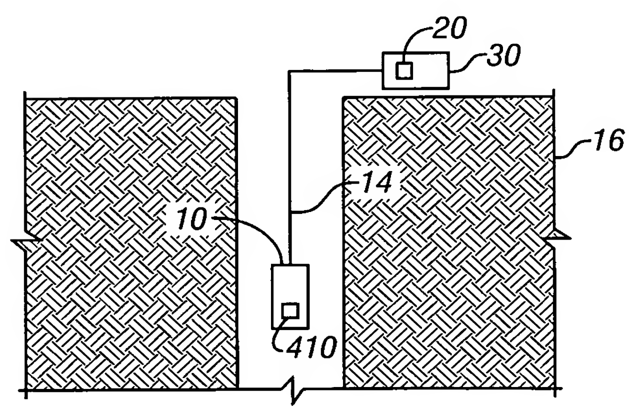

FIG. 3

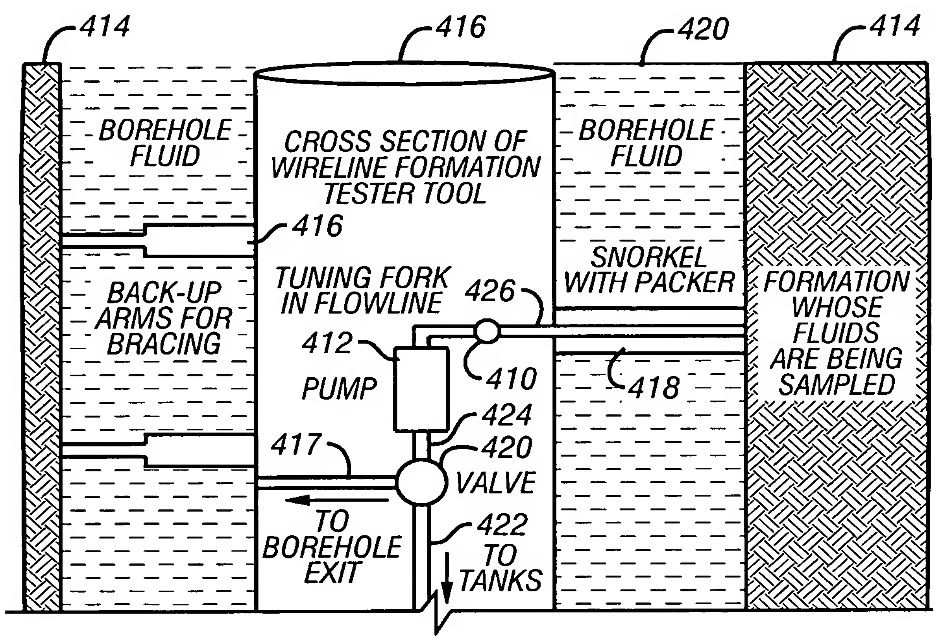
414
416
420
414
BOREHOLE FLUID
CROSS SECTION OF WIRELINE FORMATION TESTER TOOL
BOREHOLE FLUID
416
SNORKEL WITH PACKER
TUNING FORK IN FLOWLINE
426
BACK-UP ARMS FOR BRACING
FORMATION WHOSE FLUIDS ARE BEING SAMPLED
412
410
PUMP
418
424
417
420
VALVE
TO BOREHOLE EXIT
422
TO TANKS

FIG. 4

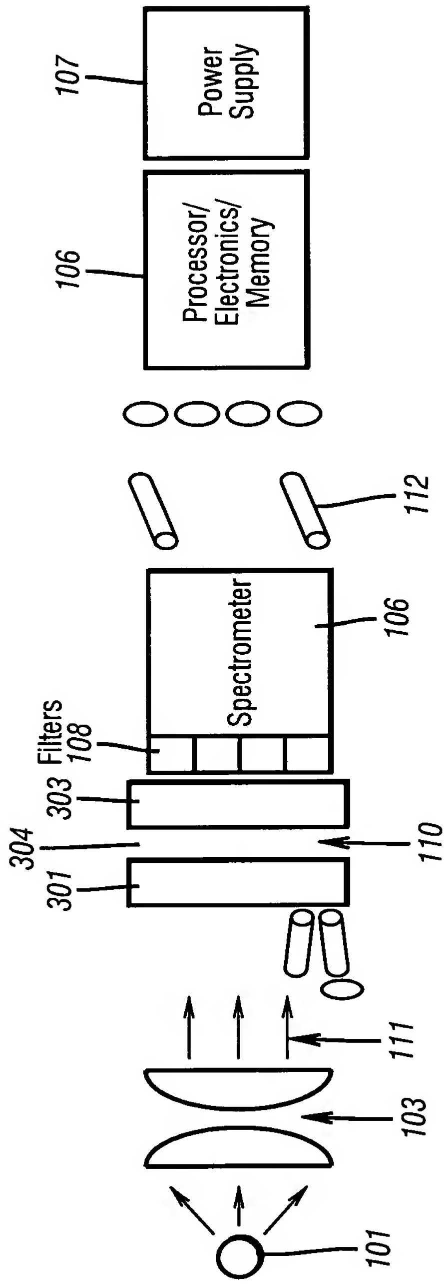
107
Power Supply
106
Processor/ Electronics/ Memory
112
Spectrometer
106
Filters 108
303
304
110
301
111
103
101

FIG. 5

Equations Correlating Weight Fraction Methane in Mixtures of Crude Oil and Methane to Optical Absorbance and Temperature

Methane Weight Fraction = METHWTF = B0 + B1 * Var1 + B2 * Var2 + B3 * Var3 + B4 * Var4 ...

Regression Summary for Dependent Variable: METHWRF
R = .98093203 R^2 = .96222765 Adjusted R^2 = .96151158
F(4,211) = 1343.8 p<0.0000 Std. Error of estimate: .04992

	B
	0.06514 = B0 = Intercept
Var1 = SQ70-82	11.1756 = B1
Var2 = TEMP_C	0.00087 = B2
Var3 = SRSA1670	-2.66167 = B3
Var4 = SRSA1682	2.63245 = B4

Regression Summary for Dependent Variable: METHWRF
R = .98190316 R^2 = .96413381 Adjusted R^2 = .96327986
F(5,210) = 1129.0 p<0.0000 Std. Error of estimate: .04876

	B
	0.03143 = B0 = Intercept
Var1 = SRSA1670	2.53111 = B1
Var2 = SRSA1682	-2.55766 = B2
Var3 = SQ70-82	11.9135 = B3
Var4 = TEMP_C	0.0019 = B4
Var5 = TEMP_SQR	-6.2E-06 = B5

SQ70-82 = SQUARE(Absorbance_at_1670_nm - Absorbance_1682_nm)
SRSA1670 = SQRT(Absorbance_at_1670_nm)
SRSA1682 = SQRT(Absorbance_at_1682_nm)
TEMP_C = Temperature in Degrees Centigrade
TEMP_SQR = Square of Temperature in Degrees C

Equation for Density of Methane [g/cc] as a Function of Pressure and Temperature from 100- 30,000 psia and 75-200 C is fitted by Adj. R^2 = .99911359

	B	
	2.771E-03 = Intercept	
P	2.480E-05	
P^2	-1.120E-09	for Pressure in psi
P^3	1.808E-14	
T^2	-1.308E-07	for Temperature in C
(P/T)	1.455E-03	
$(P/T)^2$	-4.922E-06	
$(P/T)^3$	5.934E-09	

Equation for Optical Absorbance per mm of Methane as a Function of Density and Wavelength at 11 nm FWHM, Center λ range of 1668-1684 nm, for 100-30,000 psia and 75-200 C, is fitted by Adj. R^2 = .94145159

	B	
	-19.9061 = Intercept	
Methane Density	0.7747	for Density in g/cc
WaveNumber/1000	3.3326	

Equations Relating Gas Oil Ratio, GOR, to Weight Fraction of Methane, f_M, and Stock Tank Density, ρo, of Oil

1bbl = 0.159 m^3 = 5.615 cu ft = 42 U.S. gal
1 Standard Cubic Foot (SCF) or Methane Gas at 14.7 psia & 60°F is 0.042358 lbs = 19.21327 grams.
Density of Methane at 60°F and 14.7 psia is 0.0006787 gr/cc = 0.04258 lbm/ft^3
Letting V = Volume, W = Weight, ρ = Density, and using subscripts M for Methane and O for Oil,
GOR = $V_{Methane}$[SCR] / V_{Oil}[bbls] = $\{W_M / (19.21 \text{ g/SCF})\} / \{(W_O/\rho_O)\ (1 \text{ bbl}/158.983 \text{ cc})\}$
Letting f_M = Weight Fraction of Methane,
GOR = $8274.62\ \rho_O / (1/f_M - 1)$
$f_M = W_M / (W_M + W_O) = \rho_M V_M / (\rho_M V_M + \rho_O V_O)$ so $W_O = W_M / (1/f_M - 1)$ which substitutes into above.
$f_M = 1 / (1 + 8274.62 * \rho_O / GOR)$ where W_G and W_O are in grams, ρ_O is in g/cc, and f_M = Wt. Frac. of Methane

FIG. 6

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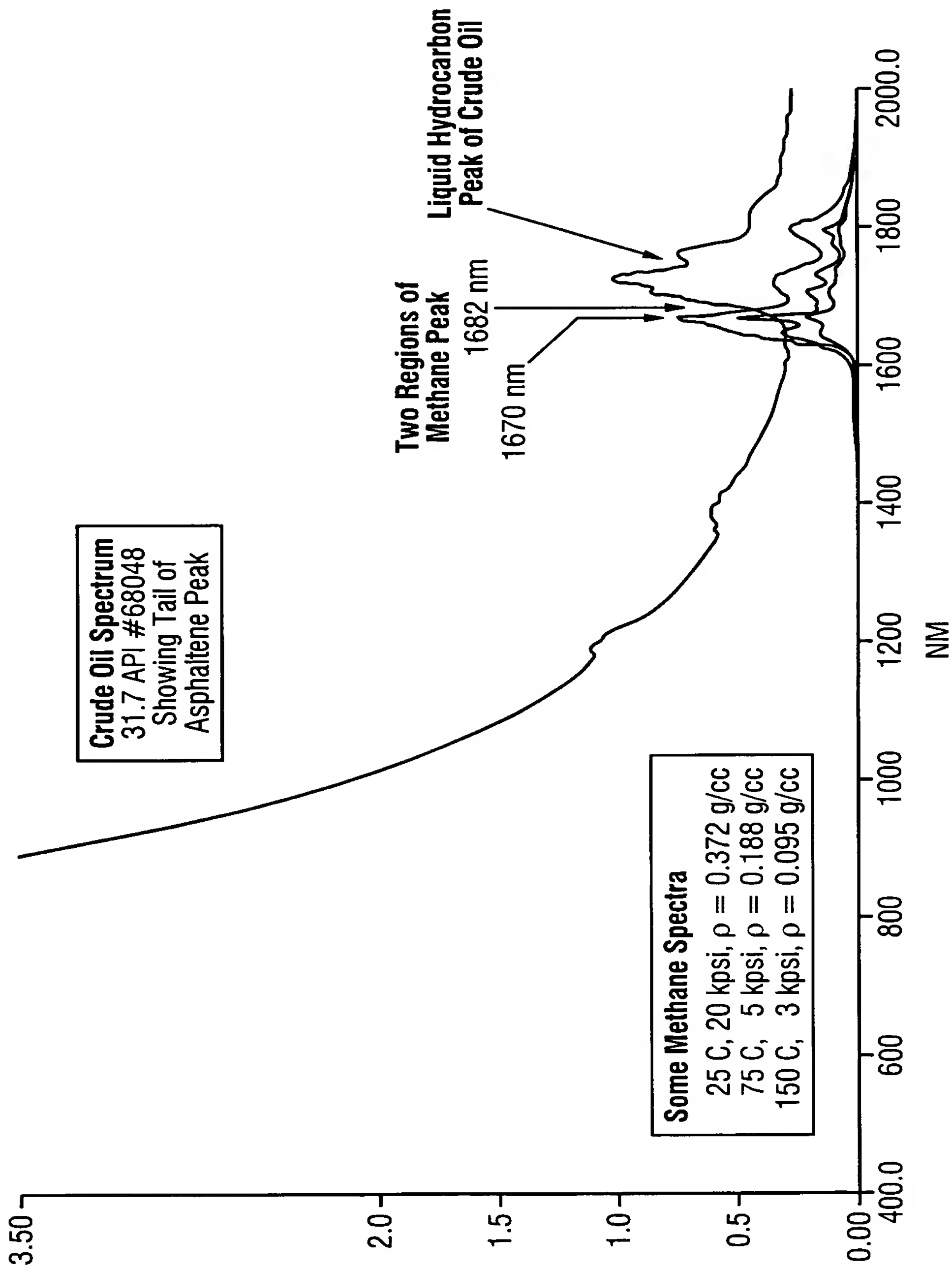

FIG. 7

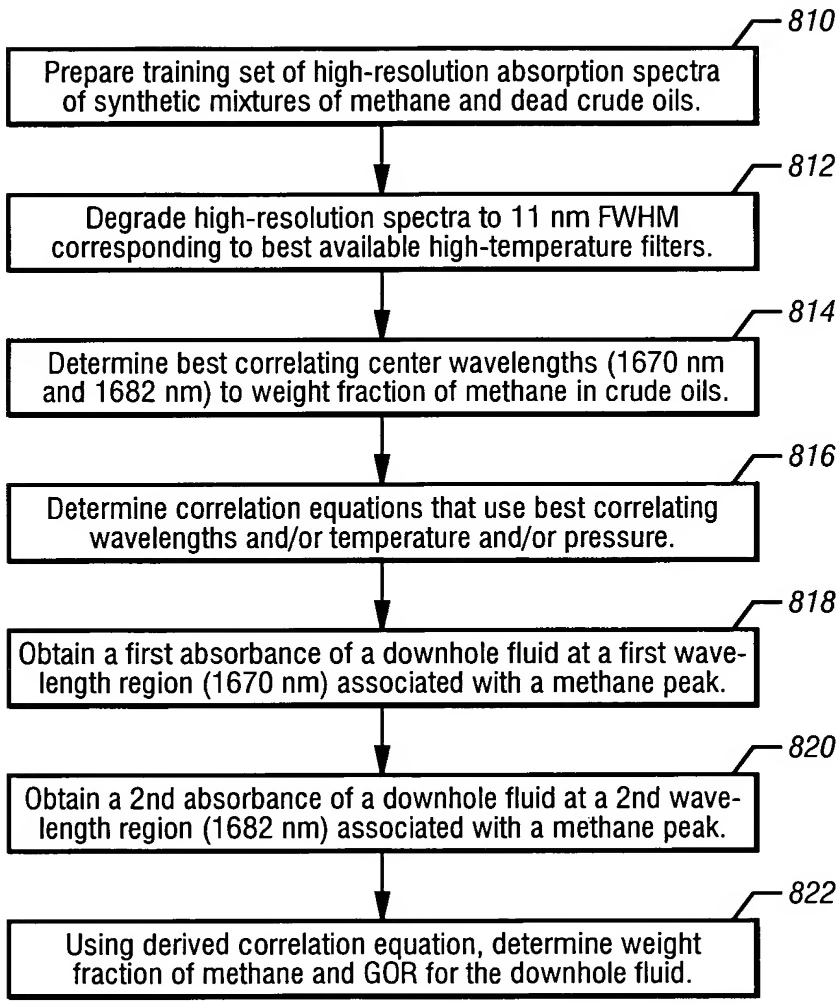
810
Prepare training set of high-resolution absorption spectra of synthetic mixtures of methane and dead crude oils.
812
Degrade high-resolution spectra to 11 nm FWHM corresponding to best available high-temperature filters.
814
Determine best correlating center wavelengths (1670 nm and 1682 nm) to weight fraction of methane in crude oils.
816
Determine correlation equations that use best correlating wavelengths and/or temperature and/or pressure.
818
Obtain a first absorbance of a downhole fluid at a first wavelength region (1670 nm) associated with a methane peak.
820
Obtain a 2nd absorbance of a downhole fluid at a 2nd wavelength region (1682 nm) associated with a methane peak.
822
Using derived correlation equation, determine weight fraction of methane and GOR for the downhole fluid.

FIG. 8